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Ninomiya

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(54) **IMAGE FORMING APPARATUS ENSURING SHORT WARM-UP TIME BY EFFICIENTLY HEATING FIXING UNIT**

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(51) **Int. Cl.**

H04N 1/00 (2006.01)
G03G 15/20 (2006.01)
G03G 15/00 (2006.01)

(52) **U.S. Cl.**

CPC ***G03G 15/2039*** (2013.01); ***G03G 15/80*** (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

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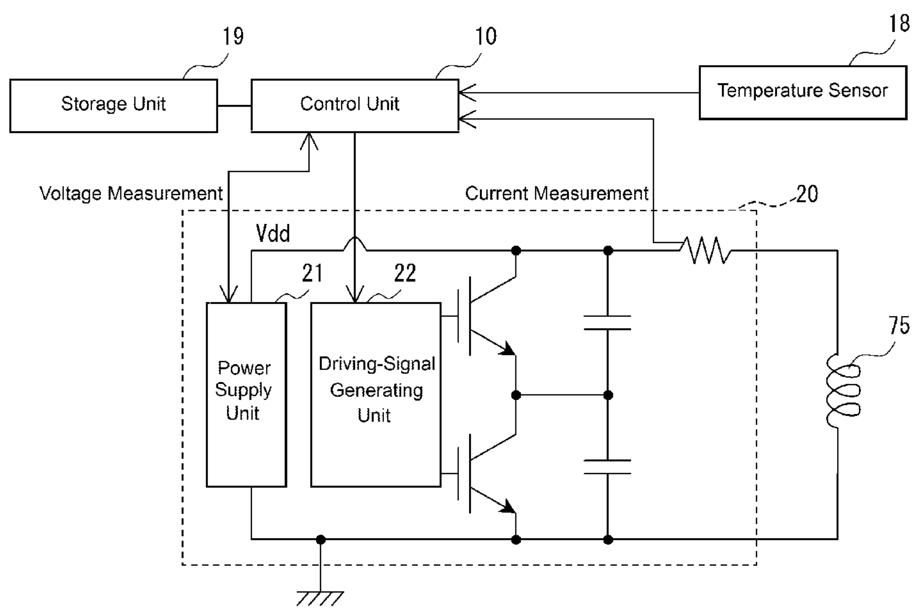
(57) **ABSTRACT**

An image forming apparatus includes a fixing unit, a temperature sensor, a storage unit, a drive-frequency initial setting unit, a power measuring unit, and a drive-frequency adjusting unit. The fixing unit is configured to perform induction heating using a coil unit. The drive-frequency initial setting unit is configured to establish an initial-setting value for a drive frequency of the coil unit based on the temperature-frequency relationship information stored in the storage unit and on the temperature measured by the temperature sensor immediately before a power activation of the fixing unit. The power measuring unit is configured to measure power consumption of the fixing unit at the drive frequency established by the drive-frequency initial setting unit. The drive-frequency adjusting unit is configured to adjust the drive frequency of the coil unit based on the power consumption measured by the power measuring unit.

2 Claims, 6 Drawing Sheets



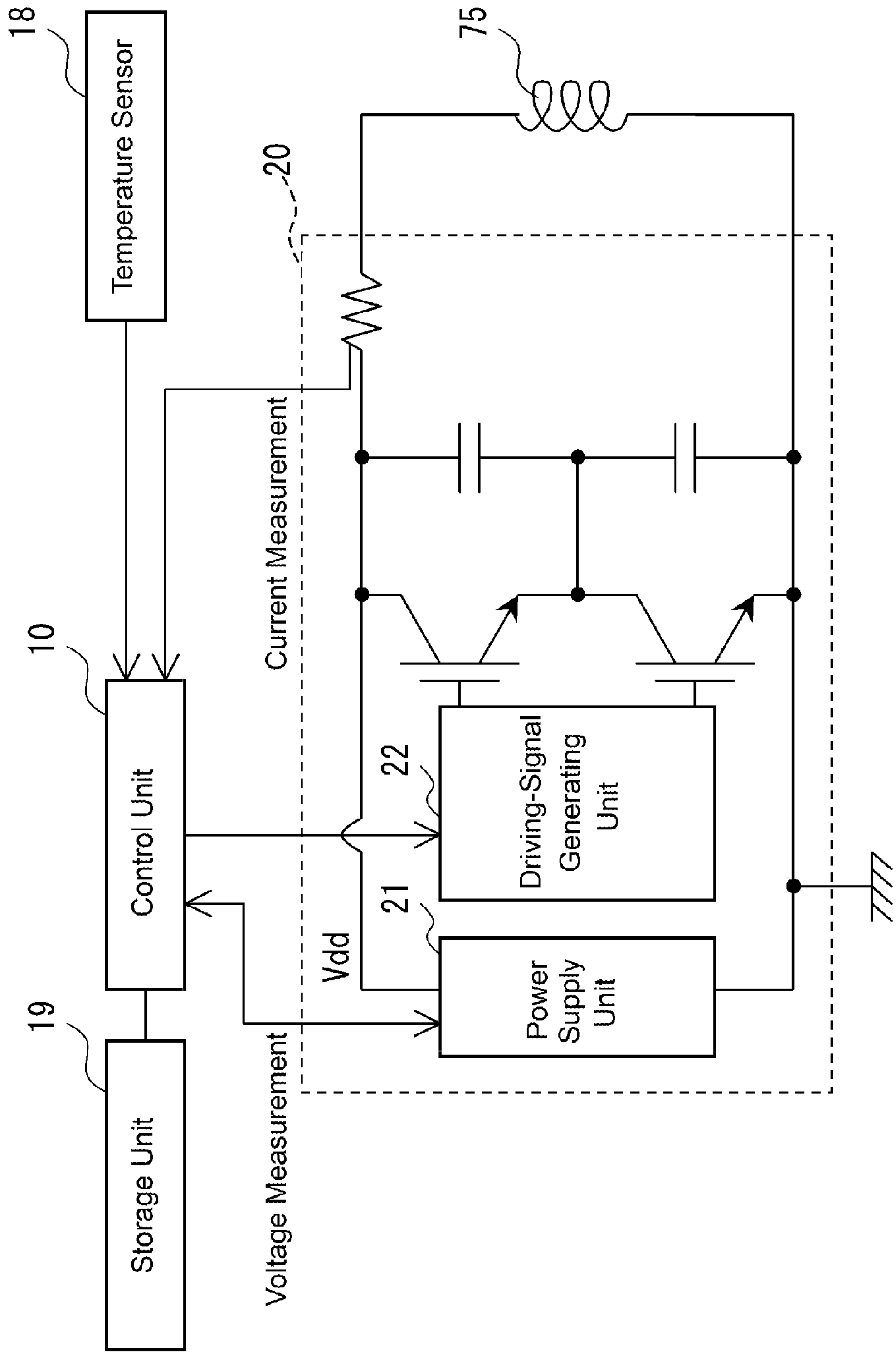

18
Temperature Sensor
75
20
10
Control Unit
Current Measurement
22
Driving-Signal Generating Unit
21
Vdd
Power Supply Unit
19
Storage Unit
Voltage Measurement

FIG. 1

FIG. 2

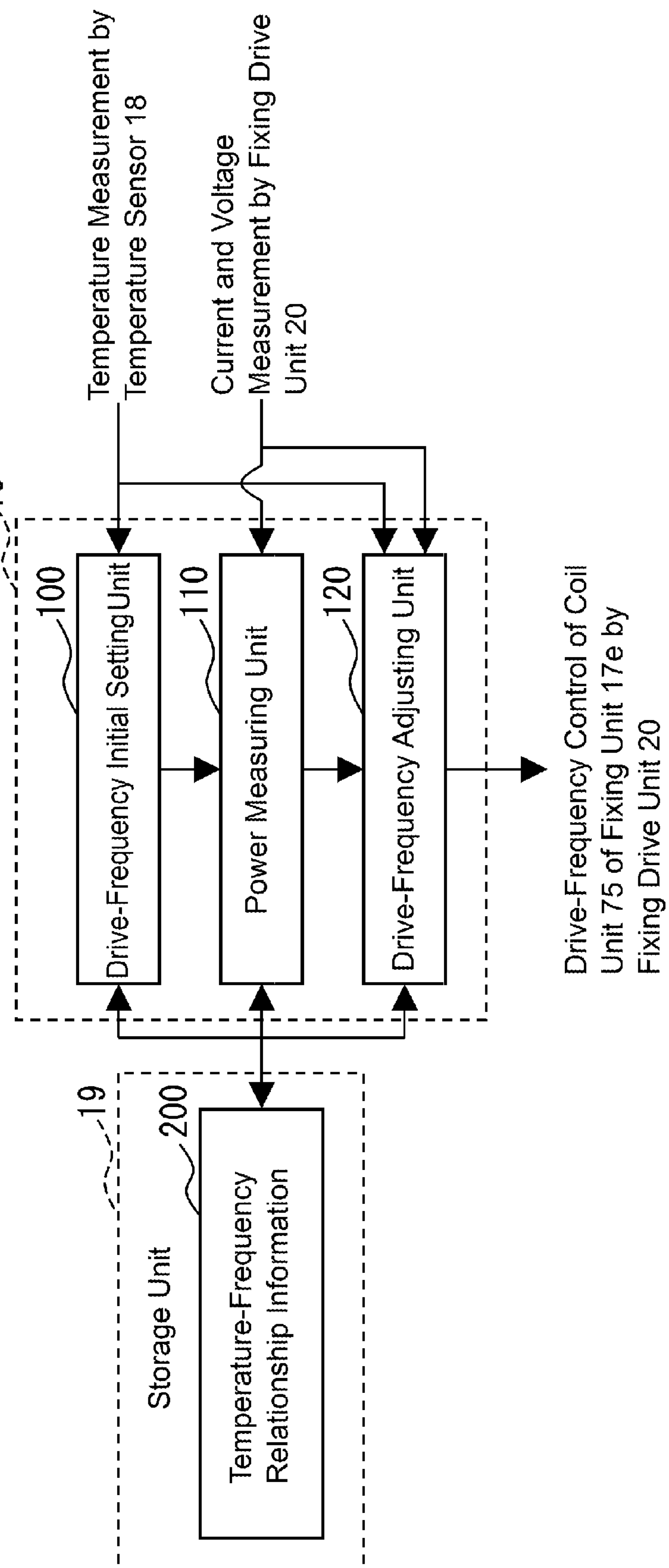

Temperature Measurement by Temperature Sensor 18
Current and Voltage Measurement by Fixing Drive Unit 20
10
100
Drive-Frequency Initial Setting Unit
110
Power Measuring Unit
120
Drive-Frequency Adjusting Unit
Drive-Frequency Control of Coil Unit 75 of Fixing Unit 17e by Fixing Drive Unit 20
19
Storage Unit
200
Temperature-Frequency Relationship Information

FIG. 3

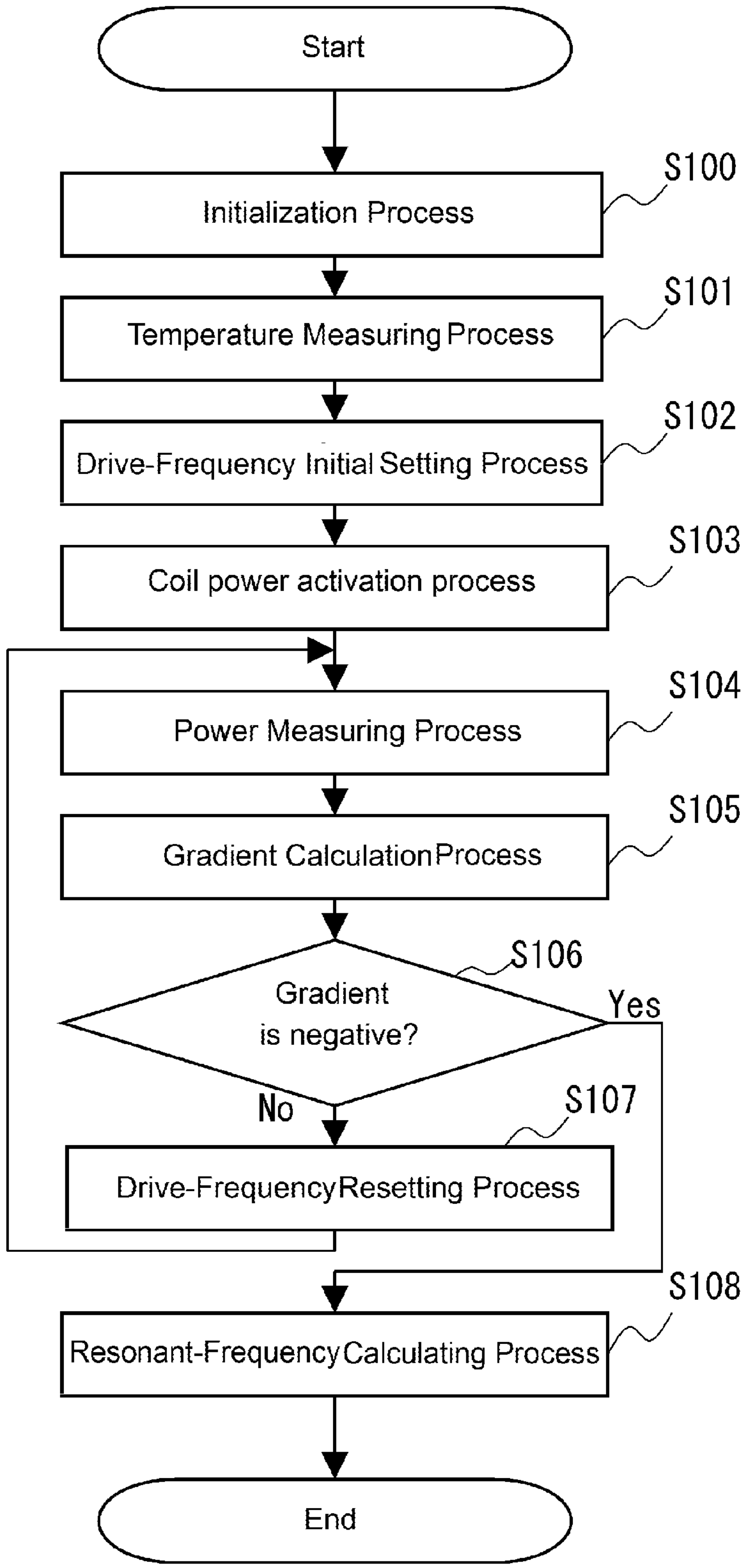
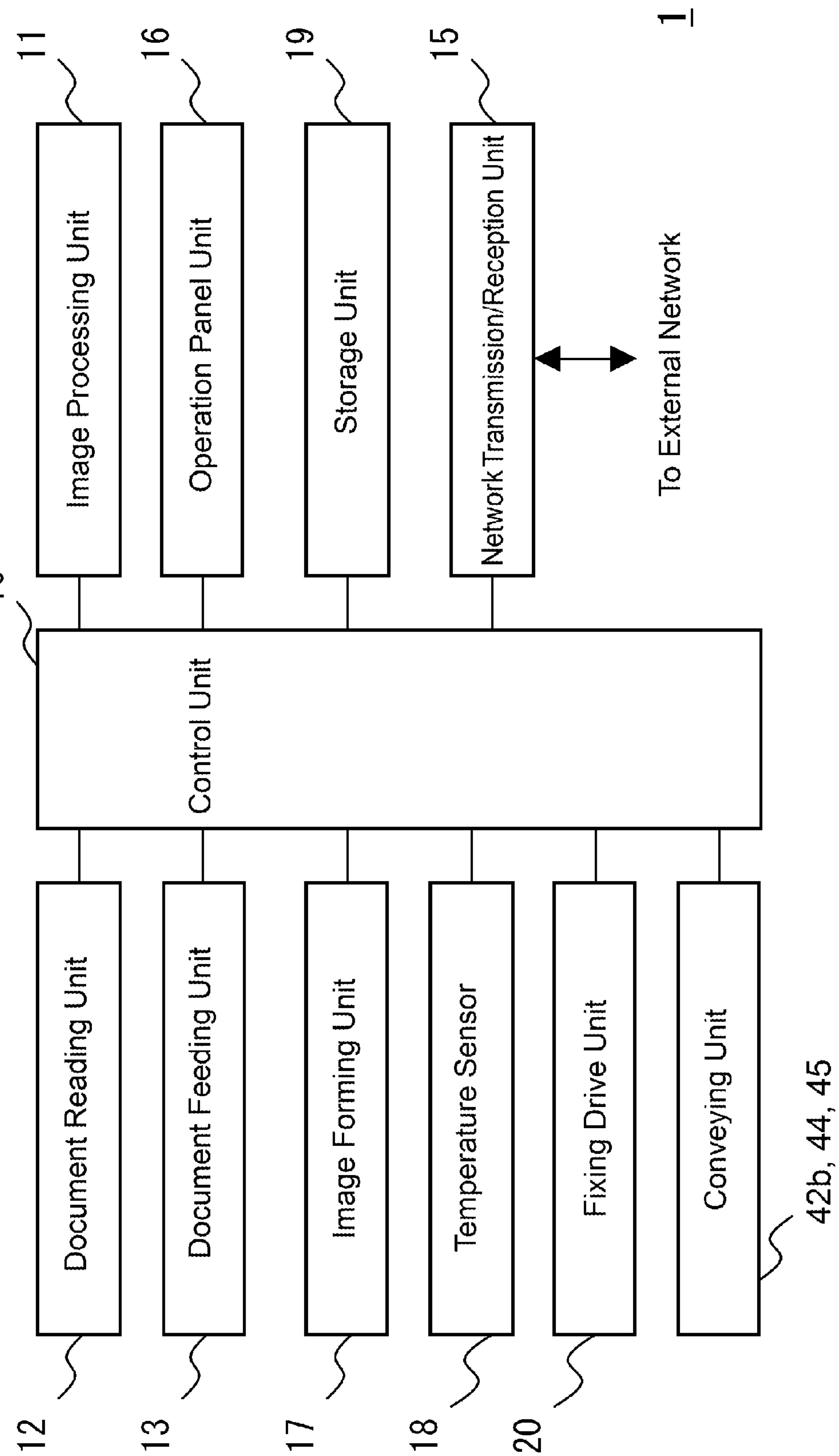
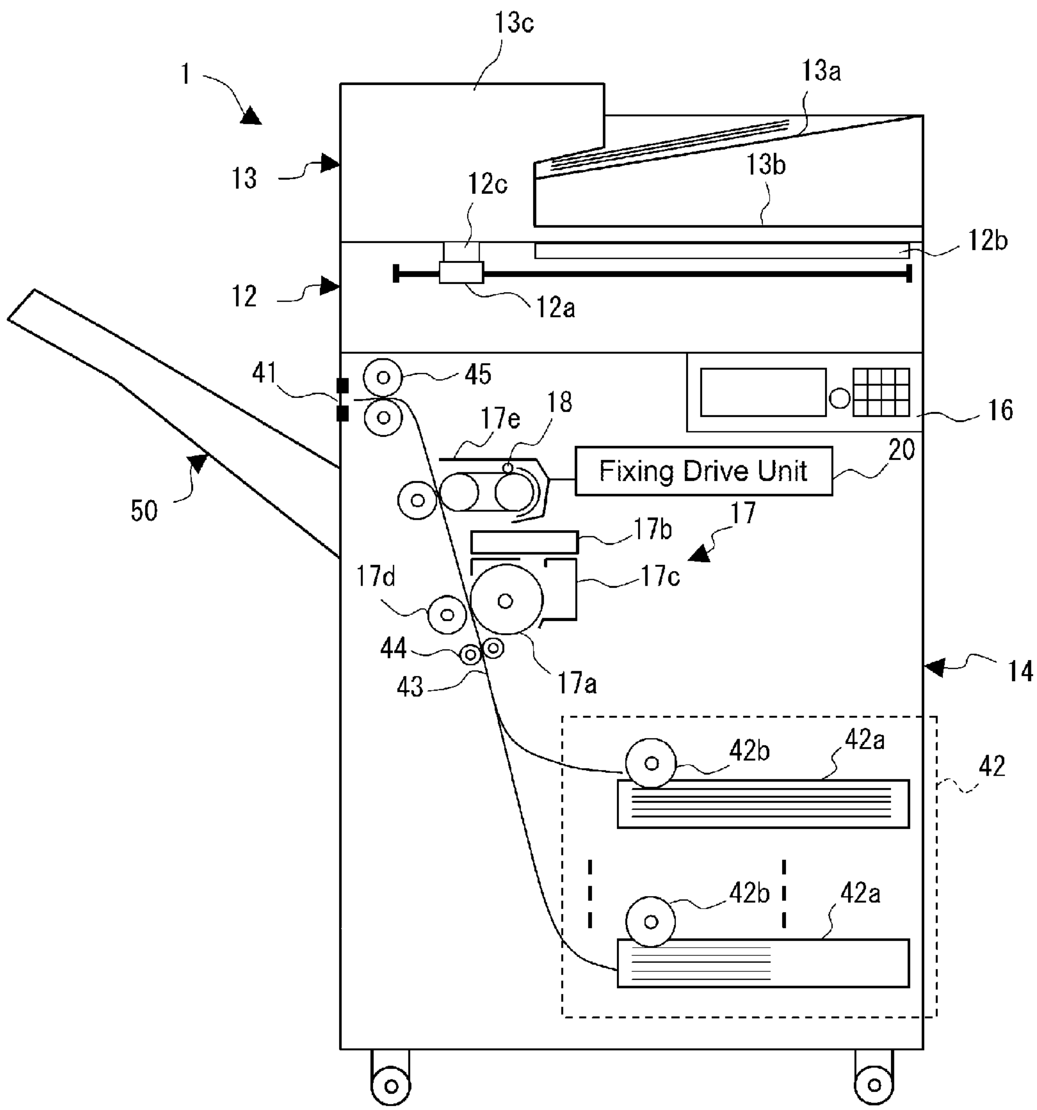

Start
Initialization Process
S100
Temperature Measuring Process
S101
Drive-Frequency Initial Setting Process
S102
Coil power activation process
S103
Power Measuring Process
S104
Gradient Calculation Process
S105
Gradient is negative?
S106
Yes
No
Drive-Frequency Resetting Process
S107
Resonant-Frequency Calculating Process
S108
End

FIG. 4



1
10
Control Unit
11
Image Processing Unit
16
Operation Panel Unit
19
Storage Unit
15
Network Transmission/Reception Unit
To External Network
12
Document Reading Unit
13
Document Feeding Unit
17
Image Forming Unit
18
Temperature Sensor
20
Fixing Drive Unit
Conveying Unit
42b, 44, 45

FIG. 5


13c
1
13a
13
12c
13b
12b
12
12a
41
45
18
16
17e
Fixing Drive Unit
20
50
17
17b
17d
17c
44
43
17a
14
42b
42a
42
42b
42a

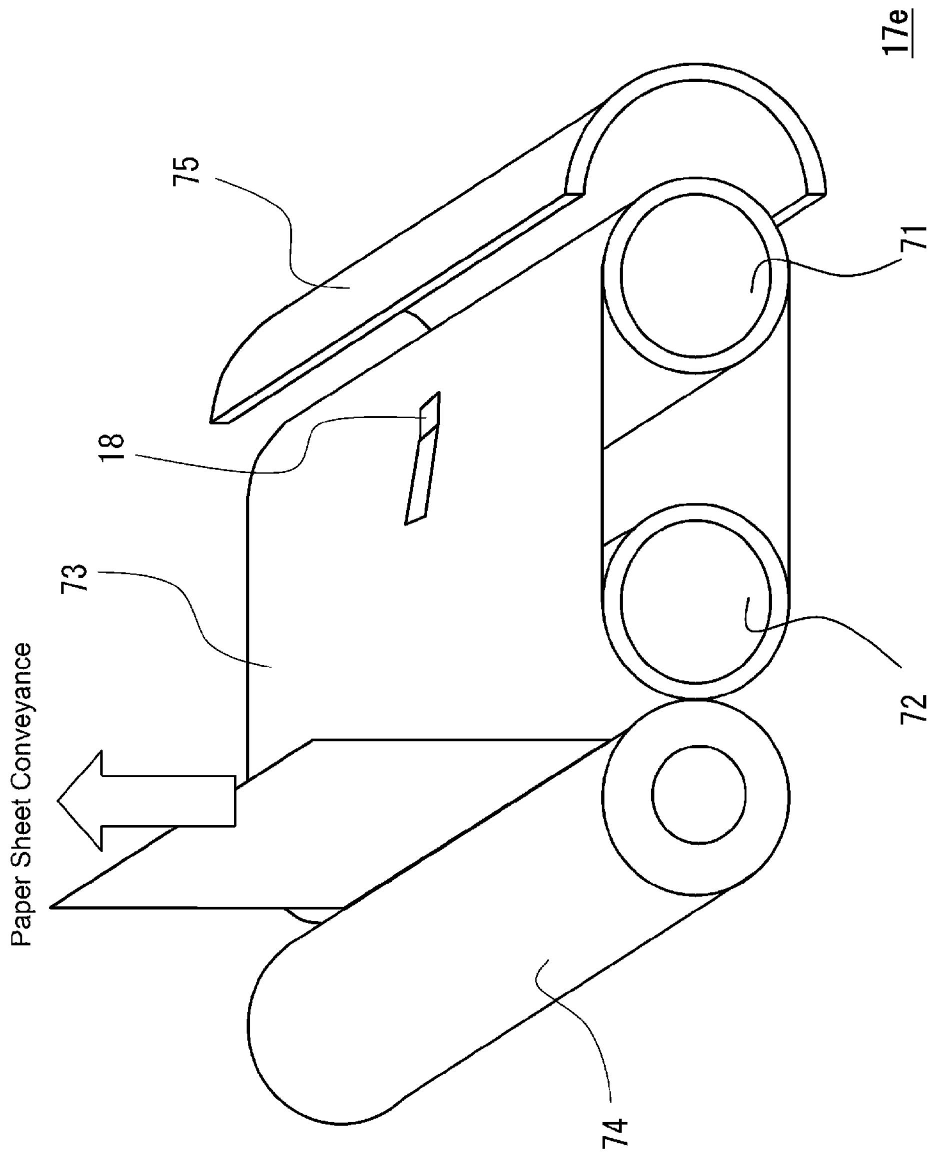


FIG. 6

IMAGE FORMING APPARATUS ENSURING SHORT WARM-UP TIME BY EFFICIENTLY HEATING FIXING UNIT

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon, and claims the benefit of priority from, corresponding Japanese Patent Application No. 2013-169819 filed in the Japan Patent Office on Aug. 19, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

Unless otherwise indicated herein, the description in this section is not prior art to the claims in this application and is not admitted to be prior art by inclusion in this section.

There is provided an image forming apparatus such as a multifunctional peripheral (MFP) that can print a document and an image. In this image forming apparatus, a recording sheet to which a toner image is transferred is heated by a fixing unit to fix the toner so as to perform image formation. As a method for heating this fixing unit, there is a method using induction heating (IH).

Here, as a conventional method of the induction heating, there is known a non-contact power transmission apparatus. The non-contact power transmission apparatus includes an oscillation circuit and performs alternating-current driving of a primary-side winding based on the output of the oscillation circuit to convert the alternate current induced in a secondary-side winding that faces the primary-side winding into a direct current so as to transmit the electric power. In the non-contact power transmission apparatus, the oscillation circuit is constituted by a variable-frequency oscillation circuit with a variable drive frequency, and the input electric power to be supplied from a power supply to the primary-side winding is detected to find the drive frequency at which the input electric power becomes maximum. The oscillation circuit is operated at this drive frequency.

SUMMARY

An image forming apparatus according to the disclosure includes a fixing unit, a temperature sensor, a storage unit, a drive-frequency initial setting unit, a power measuring unit, and a drive-frequency adjusting unit. The fixing unit is configured to perform induction heating using a coil unit. The temperature sensor is configured to measure the temperature of the fixing unit. The storage unit stores temperature-frequency relationship information indicating a relationship between the fixing unit temperature measured by the temperature sensor and a resonant frequency of the coil unit. The drive-frequency initial setting unit is configured to establish an initial-setting value for a drive frequency of the coil unit based on the temperature-frequency relationship information stored in the storage unit and on the temperature measured by the temperature sensor immediately before a power activation of the fixing unit. The power measuring unit is configured to measure power consumption of the fixing unit at the drive frequency established by the drive-frequency initial setting unit. The drive-frequency adjusting unit is configured to adjust the drive frequency of the coil unit based on the power consumption measured by the power measuring unit.

These as well as other aspects, advantages, and alternatives will become apparent to those of ordinary skill in the art by reading the following detailed description with reference where appropriate to the accompanying drawings. Further, it should be understood that the description provided in this summary section and elsewhere in this document is intended to illustrate the claimed subject matter by way of example and not by way of limitation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a system configuration of a fixing unit in an image forming apparatus according to one embodiment of the disclosure;

FIG. **2** illustrates a functional configuration of the image forming apparatus according to the one embodiment;

FIG. **3** illustrates a drive-frequency setting process according to the one embodiment;

FIG. **4** illustrates the entire configuration of the image forming apparatus according to the one embodiment;

FIG. **5** schematically illustrates the image forming apparatus according to the one embodiment; and

FIG. **6** perspectively illustrates the fixing unit and a temperature sensor according to the one embodiment.

DETAILED DESCRIPTION

Example apparatuses are described herein. Other example embodiments or features may further be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. In the following detailed description, reference is made to the accompanying drawings, which form a part thereof.

The example embodiments described herein are not meant to be limiting. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the drawings, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

Entire Configuration of Image Forming Apparatus **1** According to One Embodiment

Firstly, the entire configuration of an image forming apparatus **1** will be described with reference to FIG. **4**. The image forming apparatus **1** includes an image processing unit **11**, a document reading unit **12**, a document feeding unit **13**, a conveying unit (paper feed rollers **42***b*, a conveyance roller pair **44**, and a discharge roller pair **45**), a network transmission/reception unit **15**, an operation panel unit **16**, an image forming unit **17**, a temperature sensor **18**, a storage unit **19**, a fixing drive unit **20**, and similar member, which are connected to a control unit **10**. The control unit **10** performs operation controls of the respective units.

The control unit **10** is an information processing unit such as a general purpose processor (GPP), a central processing unit (CPU), a micro processing unit (MPU), a digital signal processor (DSP), a graphics processing unit (GPU), and an application specific processor (ASIC). The control unit **10** reads a control program stored in a ROM or an HDD of the storage unit **19**, expands this control program in the RAM, and executes this control program. This causes the control unit **10** to operate as each unit of function blocks described later. The control unit **10** performs the control of the entire apparatus corresponding to predetermined instruction information that is input from an external terminal (not illustrated) or the operation panel unit **16**.

The image processing unit **11** is an operation control unit such as a digital signal processor (DSP) and a graphics processing unit (GPU). The image processing unit **11** performs a predetermined image process on image data. For example, the image processing unit **11** performs various image processes such as scaling, print density adjustment, gradation adjustment, and image improvement. The image processing unit **11** stores the image read by the document reading unit **12** as print data in the storage unit **19**. At this time, the image processing unit **11** can also convert the print data into a file unit in a PDF, a TIFF, or a similar format.

The document reading unit **12** reads (scans) a set original document. The document feeding unit **13** conveys the original document to be read by the document reading unit **12**. The image forming unit **17** causes image formation on a recording sheet based on the data stored in the storage unit **19**, the data read by the document reading unit **12**, the data acquired from the external terminal, or similar data. The power delivery to the image forming unit **17** is stopped during a standby state for saving the electric power. Accordingly, the temperature of a fixing unit **17***e* (see FIG. **5**) of the image forming unit **17** is unintentionally reduced corresponding to a lapse of time in the standby state or similar parameter. The temperature sensor **18** is a temperature detecting sensor such as a thermistor for measuring the temperature of the fixing unit **17***e*. The conveying unit conveys a recording sheet from a sheet feed cassette **42***a*, and causes image formation on the recording sheet at the image forming unit **17**, and then conveys the recording sheet to a stack tray **50**. Here, the respective operations of the document reading unit **12**, the document feeding unit **13**, the conveying unit, the image forming unit **17**, the temperature sensor **18**, and the fixing drive unit **20** will be described later.

The network transmission/reception unit **15** is a network connection unit that includes a LAN board, a wireless transceiver, and similar member for connecting to an external network such as LAN, wireless LAN, WAN, and a mobile phone network. The network transmission/reception unit **15** transmits and receives data through a data communication line and transmits and receives a voice signal through a voice-grade telephone line.

The operation panel unit **16** includes: a display unit such as an LCD and an input unit including; a numeric keypad; a start key; a cancel key; a button for switching action modes such as copy, FAX transmission, and scanner; a button for issuing an instruction for execution of a job related to printing, transmission, storage, recording or similar operation of a selected document; a touch panel. The operation panel unit **16** acquires the instructions of various jobs of the image forming apparatus **1** from the user. Additionally, the information of each user can be input and changed in accordance with the acquired instruction of the user from the operation panel unit **16**.

The storage unit **19** is storage unit that employs a recording medium such as a semiconductor memory such as a read only memory (ROM) and a random access memory (RAM) and a hard disk drive (HDD). The RAM of the storage unit **19** holds the content of the memory by a function such as self-refreshing even during the power-saving state. The ROM and the HDD in the storage unit **19** store control programs for performing the operation control of the image forming apparatus **1**. In addition, the storage unit **19** stores account setting of the user. The storage unit **19** may include a region for a storage folder for every user.

In the image forming apparatus **1**, the control unit **10** and the image processing unit **11** may be integrally formed like a GPU Built-in CPU or a chip-on-module package. The control unit **10** and the image processing unit **11** may each incorporate a RAM, a ROM, a flash memory, or similar member. The image forming apparatus **1** may include a FAX transmission/reception unit for transmission to and reception from a facsimile.

Operation of Image Forming Apparatus **1**

Next, a description will be given of the operation of the image forming apparatus **1** according to the embodiment of the disclosure with reference to FIG. **5** and FIG. **6**. The document reading unit **12** is arranged on the upper side of a main unit **14**. The document feeding unit **13** is arranged on the upper side of the document reading unit **12**. The stack tray **50** is arranged on a discharge port **41** side of recording sheets. The discharge port **41** is formed in the main unit **14**. The operation panel unit **16** is arranged on the front side of the image forming apparatus **1**.

The document reading unit **12** includes a scanner **12***a*, a platen glass **12***b*, and a document reading slit **12***c*. The scanner **12***a* is constituted of an exposing lamp, imaging sensor such as a charge coupled device (CCD), a complementary metal oxide semiconductor (CMOS), and similar member. The scanner **12***a* is capable of moving in the conveyance direction of the original document by the document feeding unit **13**. The platen glass **12***b* is a platen constituted of a transparent member such as glass. The document reading slit **12***c* has a slit formed in a direction perpendicular to the conveyance direction of the original document by the document feeding unit **13**.

To read the original document placed on the platen glass **12***b*, the scanner **12***a* is moved to the position facing the platen glass **12***b*. Subsequently, the scanner **12***a* acquires image data by reading the original document while scanning the original document placed on the platen glass **12***b*, so as to output the acquired image data to the main unit **14**. To read the original document conveyed by the document feeding unit **13**, the scanner **12***a* is moved to the position facing the document reading slit **12***c*. Subsequently, the scanner **12***a* acquires image data by reading the original document via the document reading slit **12***c* in synchronization with the conveying operation of the original document by the document feeding unit **13**, so as to output the acquired image data to the main unit **14**.

The document feeding unit **13** includes a document placement unit **13***a*, a document discharging unit **13***b*, and a document conveying mechanism **13***c*. The original document placed on the document placement unit **13***a* is sequentially fed one by one by the document conveying mechanism **13***c*, conveyed to the position facing the document reading slit **12***c*, and then discharged to the document discharging unit **13***b*. Here, the document feeding unit **13** is constituted to be retractable. Lifting up the document feeding unit **13** ensures opening the top surface of the platen glass **12***b*.

The main unit **14** includes the image forming unit **17**, and also includes a paper sheet feeder **42**, a paper sheet conveyance passage **43**, the conveyance roller pair **44**, and the discharge roller pair **45**. The paper sheet feeder **42** includes a plurality of sheet feed cassettes **42***a* and a plurality of paper feed rollers **42***b*. The sheet feed cassettes **42***a* store respective recording sheets having different sizes or orientations. The paper feed roller **42***b* feeds the recording sheet one by one to the paper sheet conveyance passage **43** from the sheet feed cassette **42***a*. The paper feed roller **42***b*, the conveyance roller pair **44**, and the discharge roller pair **45** function as the conveying unit. The recording sheet, which is fed to the paper sheet conveyance passage **43** by the paper feed roller **42***b*, is conveyed toward the image forming unit **17** by the conveyance roller pair **44**. The conveyed recording sheet undergoes positioning and adjustment of a margin width at the distal end of the paper sheet at predetermined timing, and then is conveyed to the inside of the image forming unit **17**. The recording sheet that has been conveyed to the inside of the image forming unit **17** and undergone recording is discharged to the stack tray **50** by the discharge roller pair **45**.

The image forming unit **17** includes a photoreceptor drum **17***a*, an exposing unit **17***b*, a developing unit **17***c*, a transfer unit **17***d*, and the fixing unit **17***e*. The exposing unit **17***b* is an optical unit that includes a laser device, a mirror, and a lens, and similar member. The exposing unit **17***b* outputs a light or similar radiation based on the image data to expose the photoreceptor drum **17***a*, so as to form an electrostatic latent image on the surface of the photoreceptor drum **17***a*. The developing unit **17***c* is a developer unit that develops the electrostatic latent image formed on the photoreceptor drum **17***a* using a toner. The developing unit **17***c* forms a toner image based on the electrostatic latent image on the photoreceptor drum **17***a*. The transfer unit **17***d* transfers the toner image formed on the photoreceptor drum **17***a* by the developing unit **17***c* to the recording sheet. The fixing unit **17***e* heats the recording sheet to which the toner image is transferred by the transfer unit **17***d* so as to fix the toner image to the recording sheet.

With reference to FIG. **6**, the fixing unit **17***e* includes, for example, a heating roller **71**, a melting roller **72**, a heating belt **73**, a pressure roller **74**, and a coil unit **75**. The heating belt **73** is a belt for fixing the toner onto the recording sheet, and is suspended between the heating roller **71** and the melting roller **72**. The pressure roller **74** is a roller for pressing the paper sheet against the heating belt **73**, and is arranged to have the outer peripheral surface in contact with the heating belt **73**. The coil unit **75** is arranged in the peripheral area of the heating roller **71** at a distance from the heating roller **71**.

For example, the heating roller **71** includes an iron cored bar roller in a cylindrical shape and a release layer (such as a PFA layer). The release layer is formed on the outer peripheral surface of the iron coredbar roller, and has a thickness dimension equal to or more than 0.2 mm and equal to or less than 1.0 mm. The heating roller **71** is formed in a cylindrical shape with an outer diameter of 30 mm.

For example, the melting roller **72** is formed in a cylindrical shape, and includes a cored bar roller and a sponge layer. The cored bar roller is formed of stainless steel and has an outer diameter of 45 mm. The sponge layer is formed of a silicone rubber that has a thickness equal to or more than 5 mm and equal to or less than 10 mm, and covers the outer peripheral surface of the cored bar roller.

For example, the heating belt **73** includes an electroformed nickel substrate, a silicone rubber layer, and a release layer (such as a PFA layer). The electroformed nickel substrate has a thickness dimension equal to or more than about 30 μm and equal to or less than about 50 μm. The silicone rubber layer is laminated on the electroformed nickel substrate. The release layer is formed on the silicone rubber layer. The heating belt **73** is formed of a material with a high thermal conductivity so as to be appropriate for heating.

For example, the pressure roller **74** includes a cored bar roller formed of stainless steel, a sponge layer, and a release layer (such as a PFA layer). The sponge layer is formed of a silicone rubber that has a thickness equal to or more than 2 mm and equal to or less than 5 mm, and covers the outer peripheral surface of the cored bar roller. The pressure roller **74** is formed in a cylindrical shape with an outer diameter of 50 mm. The cored bar roller of the pressure roller **74** may be formed using, for example, Fe or Al. On this core material, a silicone rubber layer may be formed. Further, a fluororesin layer may be formed on the superficial layer of the silicone rubber layer.

The coil unit **75** is an exciting coil unit for performing induction heating by electromagnetic induction. When a high-frequency wave is applied from the fixing drive unit **20** to the coil unit **75**, free electrons within the metal of the heating roller **71** and the heating belt **73** move due to a change of magnetic flux and then heat generation occurs, in the heating roller **71** and the heating belt **73**, due to resistive loss. This coil unit **75** may be provided by dividing the exciting coil into a plurality of pieces.

The temperature sensor **18** is a sensor such as a thermistor that detects the temperatures of the heating roller **71**, the heating belt **73**, and similar member so as to measure the temperature of the fixing unit **17***e*. For example, the temperature sensor **18** is supported by a leaf spring or similar member to have a range of motion of about several mm, and is pressed against the outer peripheral surface of the heating belt **73**. The temperature sensor **18** detects the change in electrical resistance or similar change corresponding to the temperatures of the heating roller **71** and the heating belt **73**. The signal representing temperature detected by the temperature sensor **18** undergoes A/D conversion or similar process, and then is measured as the temperature of the fixing unit **17***e*. Here, a plurality of the temperature sensors **18** may be provided to more accurately calculate the temperatures of the heating roller **71** and the heating belt **73**.

Configuration of Control System for Fixing Unit **17***e* of Image Forming Apparatus **1**

A description will be given of the configuration of a control system for the fixing unit **17***e* of the image forming apparatus **1** illustrated in FIG. **5** above with reference to FIG. **1**. With reference to FIG. **1**, the control system for the fixing unit **17***e* includes the control unit **10**, the storage unit **19**, the temperature sensor **18**, the fixing drive unit **20**, and the coil unit **75**. The control unit **10** refers to the storage unit **19** based on the temperatures of the heating roller **71** and the heating belt **73** (see FIG. **6**) measured by the temperature sensor **18**, to set a drive frequency to a driving-signal generating unit **22** of the fixing drive unit **20**. The control unit **10** refers to the information stored in the storage unit **19** based on the electric power calculated from the current that has flowed through the coil unit **75**, to control the driving-signal generating unit **22** so as to adjust the drive frequency. The storage unit **19** stores, for example, a table showing the relationship between a temperature detected using the temperature sensor **18** and a resonant frequency of the coil unit **75** as a factory default. The fixing drive unit **20** is a high-frequency power supply circuit or similar circuit for applying a high-frequency wave to the coil unit **75**. The fixing drive unit **20** supplies the driving signal generated by the driving-signal generating unit **22** to two high-frequency switching transistors or similar member connected in series to the power supply voltage applied from a power supply unit **21**, so as to alternately drive the respective switching transistors, thus causing a flow of a high-frequency current through the coil unit **75**. The coil unit **75** receives a flow of a high-frequency current at the drive frequency set by a drive-frequency adjusting unit **120** (see FIG. **2**) of the fixing drive unit **20**. This causes a high-frequency magnetic flux in the coil unit **75** and then causes eddy currents in the heating roller **71** and the heating belt **73**, thus heating these members by Joule heat. The power supply unit **21** is a stabilized power supply in which an alternating-current voltage (AC) is rectified to be converted into a DC voltage or similar power supply. The driving-signal generating unit **22** uses a voltage-controlled oscillation circuit in which the oscillation frequency can be changed corresponding to a control voltage supplied from the control unit **10** or similar circuit to generate and output a driving signal for the high-frequency transistors or similar member.

Configuration of Control Unit **10** of Image Forming Apparatus **1**

A description will be given of the detailed configuration of the control unit **10** of the image forming apparatus **1** illustrated in FIG. **1** with reference to FIG. **2**. The control unit **10** includes a drive-frequency initial setting unit **100**, a power measuring unit **110**, and the drive-frequency adjusting unit **120**. The storage unit **19** stores temperature-frequency relationship information **200**.

The drive-frequency initial setting unit **100** establishes an initial-setting value for the drive frequency of the coil unit **75** based on the temperature-frequency relationship information **200** stored in the storage unit **19** and the temperature measured by the temperature sensor **18** immediately before the power activation of the coil unit **75** of the fixing unit **17***e*. That is, the drive-frequency initial setting unit **100** appropriately establishes the initial value for the drive frequency based on the temperature-frequency relationship information **200** stored in the storage unit **19** immediately before the electric power is output.

The power measuring unit **110** measures the power consumption of the fixing unit **17***e* at the drive frequency set by the drive-frequency initial setting unit **100**. The power measuring unit **110** calculates a power value based on a product of the voltage of the power supply unit **21** in the fixing drive unit **20** (see FIG. **1**) and a measured current.

The drive-frequency adjusting unit **120** adjusts the drive frequency of the coil unit **75** in the fixing unit **17***e* based on the electric power measured by the power measuring unit **110**. Additionally, the drive-frequency adjusting unit **120** reduces the established drive frequency by a predetermined amount, causes the power measuring unit **110** to measure the electric powers before and after the reduction in order to calculate a gradient, calculates a point immediately before the gradient is reduced and becomes negative, that is, a point at which the output power becomes local maximum as a resonant frequency, and adjusts the drive frequency to the calculated resonant frequency. The drive-frequency adjusting unit **120** adjusts the drive frequency during power activation or during recovery from the power-saving state. The drive-frequency adjusting unit **120** repeats the calculation of the resonant frequency at warm-up time during power activation or during recovery from the power-saving state such as a sleep mode.

The temperature-frequency relationship information **200** is the information indicative of the relationship between the temperature measured by the temperature sensor **18** and the resonant frequency of the coil unit **75** in the fixing unit **17***e*. The temperature-frequency relationship information **200** is, for example, a table describing a resonant frequency corresponding to a temperature in a predetermined range. The drive-frequency initial setting unit **100** can read out the resonant frequency corresponding to the temperature measured by the temperature sensor **18** from the temperature-frequency relationship information **200** so as to set the drive frequency. The relationship between the temperature information of the fixing unit **17***e* and the resonant frequency may be actually measured when the coil unit **75** is mounted on the image forming apparatus **1**, and temperature-frequency relationship information **200** may be stored in the storage unit **19**. Additionally, the storage unit **19** may store the actual value of the resonant frequency set based on the value of the temperature sensor **18** by the following drive-frequency setting process in real time (actual time), so as to consider aged deterioration or similar factor.

Here, the control unit **10** of the image forming apparatus **1** may execute the control program stored in the storage unit **19** to function the drive-frequency initial setting unit **100**, the power measuring unit **110**, and the drive-frequency adjusting unit **120** or may achieve these functions using a dedicated circuit. The respective units of the above-described image forming apparatus **1** are hardware resources for performing an image forming method of the disclosure.

Drive-Frequency Setting Process by Image Forming Apparatus **1**

Next, a description will be given of the drive-frequency setting process by the image forming apparatus **1** according to the one embodiment of the disclosure with reference to FIG. **3**. The drive-frequency setting process in this embodiment measures the current temperature by the temperature sensor **18**, refers to the temperature-frequency relationship information **200** showing the relationship between the temperature and the resonant frequency, and applies a high-frequency voltage at the drive frequency corresponding to the resonant frequency, so as to quickly heat the heating roller **71** and the heating belt **73**. At this time, the power value of the electric power supplied for heating the heating roller **71** and the heating belt **73** is monitored to be fed back to the control unit **10** for adjustment. This results in heating with the maximum electric power. In the drive-frequency setting process in this embodiment, the control unit **10** mainly executes the program stored in the storage unit **19** using the hardware resources in collaboration with the respective units. The following describes the detail of the drive-frequency setting process for each step with reference to a flow chart in FIG. **3**.

Step S**100**

Firstly, the control unit **10** causes the drive-frequency initial setting unit **100** to perform an initialization process. The control unit **10** initializes the respective units for operation check during power activation or during recovery from the power-saving state due to the operation of the user through the operation panel unit **16**, the reception of job data from a terminal (not illustrated), or similar reason.

Step S**101**

Subsequently, the control unit **10** causes the drive-frequency initial setting unit **100** to perform a temperature measuring process. The control unit **10** acquires the temperature of the fixing unit **17***e* measured by the temperature sensor **18** immediately before the power activation of the coil unit **75** of the fixing unit **17***e*. This temperature varies depending on the elapsed time after the last image formation is performed by the image forming unit **17**.

Step S**102**

Subsequently, the control unit **10** causes the drive-frequency initial setting unit **100** to perform a drive-frequency initial setting process. The control unit **10** reads out the temperature-frequency relationship information **200** from the storage unit **19**. The control unit **10** acquires the value of the resonant frequency of the coil unit **75** corresponding to the temperature of the fixing unit **17***e* measured by the temperature sensor **18** from the temperature-frequency relationship information **200**. This value is set to the initial-setting value for the drive frequency of the coil unit **75**. The control unit **10** establishes the acquired initial-setting value for the drive frequency for the driving-signal generating unit **22** of the fixing drive unit **20**. That is, the control unit **10** establishes the initial-setting value of the drive frequency based on the temperature of the fixing unit **17***e* immediately before the high-frequency power supply circuit (the fixing drive unit **20**) starts to output electric power.

Step S103

Subsequently, the control unit **10** causes the drive-frequency initial setting unit **100** to perform a coil power activation process. The control unit **10** turns on the power supply unit **21** (see FIG. **1**) of the fixing drive unit **20** to generate a DC voltage at a predetermined voltage level. Thus, the high-frequency voltage at the established drive frequency is applied to the coil unit **75**.

Step S104

Here, the control unit **10** causes the power measuring unit **110** to perform a power measuring process. The control unit **10** measures the electric power consumed by the fixing drive unit **20**. The control unit **10** performs a calculation of a product of the voltage of the power supply unit **21** (see FIG. **1**) and a measured current or similar operation to calculate the power value, so as to measure the power consumption.

Step S105

Subsequently, the control unit **10** causes the drive-frequency adjusting unit **120** to perform a gradient calculation process. When the power value has been previously measured, the control unit **10** performs a subtraction between this previously measured power value and the power value during power activation at the established drive frequency or similar operation to calculate the gradient. That is, for the drive frequency to be output, the control unit **10** reestablishes the setting value that is set by reducing the setting value based on the temperature of the fixing unit **17***e* by a predetermined amount as described later, and calculates an increasing rate of the power value measured before and after the resetting or similar value as the gradient. Here, the control unit **10** does not calculate the gradient when only power value measured at the time of setting the initial-setting value has been calculated.

Step S106

Subsequently, the control unit **10** causes the drive-frequency adjusting unit **120** to determine whether or not the gradient is negative. The control unit **10** makes a determination of "Yes" when the gradient is calculated and the calculated gradient is negative, that is, the power value is reduced. Otherwise, the control unit **10** makes a determination of "No." In the case of "Yes," the control unit **10** causes the process to proceed to Step S**108**. In the case of "No," the control unit **10** causes the process to proceed to Step S**107**.

Step S107

When the calculated gradient is not negative, the control unit **10** causes the drive-frequency adjusting unit **120** to perform a drive-frequency resetting process. The control unit **10** reduces the set drive frequency by a predetermined amount so as to reset the drive frequency to the driving-signal generating unit **22** of the fixing drive unit **20**. This predetermined amount may be set based on information such as the variation in resonant frequency of the coil unit **75** and the accuracy of the driving-signal generating unit **22**. Subsequently, the control unit **10** returns the process to Step S**104**.

Step S108

When the calculated gradient is negative, the control unit **10** causes the drive-frequency adjusting unit **120** to perform a resonant-frequency calculating process. The control unit **10** calculates the drive frequency immediately before the calculated gradient becomes negative, that is, when the output power becomes local maximum, as a resonant frequency. The control unit **10** reestablishes the drive frequency of the driving-signal generating unit **22** in the fixing drive unit **20** to this resonant frequency. The control unit **10** may repeat the respective processes in the above-described drive-frequency setting process at warm-up time at the power activation of the image forming unit **17** or during recovery from the power-saving state. Then, the drive-frequency setting process according to the embodiment of the disclosure is terminated.

With the configuration as described above, the following effects can be obtained. A conventional technique for charging a mobile electronic device has not been able to adjust the drive frequency at high speed. In contrast, the image forming apparatus **1** according to the embodiment of the disclosure includes the fixing unit **17***e* that performs induction heating on the heating roller **71** and the heating belt **73** using the coil unit **75** having a coil. The image forming apparatus **1** includes the temperature sensor **18**, the storage unit **19**, the drive-frequency initial setting unit **100**, the power measuring unit **110**, and the drive-frequency adjusting unit **120**. The temperature sensor **18** mainly detects the temperatures of the heating roller **71** and the heating belt **73** to measure the temperature of the fixing unit **17***e*. The storage unit **19** stores the temperature-frequency relationship information **200** showing the relationship between the temperature of the fixing unit **17***e* measured by the temperature sensor **18** and the resonant frequency of the coil unit **75**. The drive-frequency initial setting unit **100** establishes the initial-setting value for the drive frequency of the coil unit **75** based on the temperature-frequency relationship information **200** stored in the storage unit **19** and the temperature measured by the temperature sensor **18** at the power activation of the fixing unit **17***e*. The power measuring unit **110** measures the power consumption of the fixing unit **17***e* at the drive frequency set by the drive-frequency initial setting unit **100**. The drive-frequency adjusting unit **120** adjusts the drive frequency of the coil unit **75** based on the electric power measured by the power measuring unit **110**.

With this configuration, using the temperature-frequency relationship information **200**, which is the relationship between the temperature of the fixing unit **17***e* and the resonant frequency, ensures quickly searching the appropriate resonant frequency so as to find out the resonant frequency at higher speed and set the resonant frequency. The fixing drive unit **20** for the fixing unit **17***e* can output a high-frequency wave at this resonant frequency, supply the appropriate electric power to the coil unit **75**, and quickly heat the heating roller **71** and the heating belt **73**. That is, the maximum output power, which is set by the high-frequency power supply circuit of the fixing drive unit **20**, can be supplied for heating the heating roller **71** and the heating belt **73**. Thus, the warm-up after power activation of the image forming apparatus **1** and the recovery from the power-saving state are completed in the shortest time. This ensures reduction in waiting time required for warm-up and the recovery so as to improve the convenience for the user.

In the image forming apparatus **1** according to the embodiment of the disclosure, the drive-frequency adjusting unit **120** reduces the drive frequency from the setting value by a predetermined amount, causes the power measuring unit **110** to measure the electric powers before and after the reduction so as to calculate a gradient, calculates the drive frequency immediately before the gradient is reduced and becomes negative as a resonant frequency, and adjusts the drive frequency to the calculated resonant frequency. This configuration can facilitate changing the drive frequency from the initial-setting value set by the drive-frequency initial setting unit **100** to the appropriate resonant frequency in a short time.

In the image forming apparatus **1** according to the embodiment of the disclosure, the drive-frequency adjusting unit **120** adjusts the drive frequency during power activation or during recovery from the power-saving state. Accordingly, adjusting the drive frequency during power activation or during recovery from the power-saving state at high speed ensures efficient heating of the fixing unit **17***e* so as to ensure the shortest warm-up time during power activation and/or the shortest recovery time from the power-saving state.

Additionally, compared with conventional electric power supply to a mobile electronic device, conventional heating of a pan using IH, or similar method, the image forming apparatus **1** in which the components are secured have a smaller variation range of the load side. That is, in the image forming apparatus **1** that includes the fixing unit **17***e* using IH, the coil unit **75** on the load side is secured by screw or similar method. Thus, impedance change due to a positional shift does not occur. Additionally, component variation does not occur unless the coil unit **75** is replaced due to failure or similar reason.

Accordingly, the image forming apparatus **1** of this embodiment can store the impedance change on the load side due to component variation of the coil unit **75** and variation in inside temperature of the image forming apparatus **1** as the temperature-frequency relationship information **200** in the storage unit **19** at the time of assembly or similar time. Thus, the image forming apparatus **1** can narrow down the adjustment range of the drive frequency so as to quickly set the resonant frequency. That is, this temperature-frequency relationship information **200** can compensate variation in impedance of the resonance coil and the resonance capacitor due to component variation and non-linear variation in impedance due to the difference in inside temperature of the image forming apparatus **1**, so as to quickly heat the heating roller **71** and the heating belt **73** with the maximum electric power. The fixing drive unit **20** can always supply the coil with the maximum electric power to be set by the high-frequency power supply circuit. This ensures shortening the warm-up time and the recovery time from the power-saving state.

Other Embodiments

In the embodiment of the disclosure, it has been described the configuration in which the resonant frequency is calculated by reducing the drive frequency from the initial frequency by the predetermined amount. However, the appropriate resonant frequency may be calculated such that the control unit **10** increases the drive frequency by a predetermined amount or repeats reducing and increasing the drive frequency by a predetermined amount. Furthermore, the predetermined amount may be set to be variable and reduced each time the drive-frequency resetting process described above is done so as to converge to the optimal value. Additionally, since the inside temperature is increased after the electric power is supplied, the control unit **10** may change the drive frequency taking into consideration this increasing rate. With this configuration, the drive frequency can be set to a more appropriate value so as to efficiently supply electric power.

The above-described embodiment has been described such that the coil unit **75** heats the heating roller **71** and the heating belt **73**. However, as a possible configuration, the heating belt **73** may be formed of metal without magnetism such as copper, resin, or similar material while the heating roller **71** is mainly heated. Additionally, as a possible configuration, the heating roller **71** and the melting roller **72** may be integrally constituted. In this case, the coil unit **75** may directly heat the integrally constituted roller. That is, a configuration without using the heating belt **73** is possible. This configuration saves the cost while the process in the above-described embodiment is used as it is.

The disclosure is also applicable to an information processing apparatus other than the image forming apparatus. That is, a possible configuration employs a network scanner, a server to which a scanner is additionally connected via USB or similar interface, and similar device.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. An image forming apparatus, comprising:

a fixing unit configured to perform induction heating using a coil unit;

a temperature sensor configured to measure a temperature of the fixing unit;

a storage unit storing temperature-frequency relationship information indicating a relationship between the fixing unit temperature measured by the temperature sensor and a resonant frequency of the coil unit;

a drive-frequency initial setting unit configured to establish an initial-setting value for a drive frequency of the coil unit based on the temperature-frequency relationship information stored in the storage unit, and on the temperature measured by the temperature sensor immediately before a power activation of the fixing unit;

a power measuring unit configured to measure power consumption of the fixing unit at the drive frequency established by the drive-frequency initial setting unit; and

a drive-frequency adjusting unit configured to

adjust the drive frequency of the coil unit based on the power consumption measured by the power measuring unit,

reduce the established drive frequency of the coil unit by a predetermined amount,

cause the power measuring unit to measure power consumption of the fixing unit before and after the reduction so as to calculate a gradient from the before and after measurements,

calculate, as a resonant frequency, a drive frequency for immediately preceding where the gradient lessens and goes negative, and

adjust the drive frequency of the coil unit to the calculated resonant frequency.

2. The image forming apparatus according to claim **1**, wherein the drive-frequency adjusting unit is configured to adjust the drive frequency of the coil unit during power activation or during recovery from a power-saving state.

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